1. COSMIC RAY FLUXES*

In the lower half of the atmosphere (altitude $\lesssim 5$ km) most cosmic rays are muons. Some typical sea-level values for charged particles are given below, where

I_v flux per unit solid angle per unit horizontal area about vertical direction
$\equiv j(\theta = 0, \phi)[\theta =$ zenith angle, $\phi =$ azimuthal angle$]$;

J_1 total flux crossing unit horizontal area from above
$\equiv \int_{\theta \leq \pi/2} j(\theta, \phi)\ \cos\theta\ d\Omega\ [d\Omega = \sin\theta\ d\theta\ d\phi]$;

J_2 total flux from above (crossing a sphere of unit cross-sectional area)
$\equiv \int_{\theta \leq \pi/2} j(\theta, \phi)\ d\Omega$.

	Total Intensity	Hard ($\approx \mu^{\pm}$) Component	Soft ($\approx e^{\pm}$) Component
I_v	110	80	30 m^{-2} s^{-1} sr^{-1}
J_1	180	130	50 m^{-2} s^{-1}
J_2	240	170	70 m^{-2} s^{-1}

At 4300 m (*e.g.*, Mt. Evans or Mauna Kea) the hard component is 2.3 times more intense than at sea level.

The $p/\mu^{\pm}$ vertical flux ratio at sea level is about 3.5% at 1 GeV/c, decreasing to about 0.5% at 10 GeV/c. The $\pi^{\pm}/\mu^{\pm}$ ratio is an order of magnitude smaller.

The mean energy of muons at the ground is ≈ 4 GeV. The energy spectrum is almost flat below 1 GeV, steepens gradually to reflect the primary spectrum ($\propto E^{-2.7}$) in the 10–100 GeV range, and asymptotically becomes one power steeper ($E_\mu \gg 1$ TeV). The measurements reported above are for $E_\mu \gtrsim 225$ MeV. The angular distribution is very nearly proportional to $\cos^2\theta$, changing to sec θ at energies above a TeV (where θ is the zenith angle at production). The μ^+/μ^- ratio is 1.25–1.30.

The mean energy of muons originating in the atmosphere is roughly 300 GeV at slant depths underground $\gtrsim$ a few hundred meters. Beyond slant depths of ≈ 10 km water-equivalent, the muons are due primarily to in-the-earth neutrino interactions (roughly 1/8 interaction ton^{-1} yr^{-1} for $E_\nu > 300$ MeV, $\approx$ constant throughout the earth). These muons arrived with a mean energy of 20 GeV, and have a flux of 2×10^{-9} m^{-2} s^{-1} sr^{-1} in the vertical direction and about twice that in the horizontal, down at least as far as the deepest mines.

* Reprint of "Cosmic-ray fluxes" from the 1986 *Review*, as updated by D.E. Groom (2000). The data (by Greisen) are reported in B. Rossi, Rev. Mod. Phys. **20**, 537 (1948). See the full *Review* on Cosmic Rays for a more extensive discussion and references.